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Australian innovation part of JSF development

Studying crewing options for airborne refuelling

Taking minutes by digital secretary

LiveSpaces: intuitive workplaces of tomorrow

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The Defence Science and Technology Organisation (DSTO) is part of the Department of Defence and provides scientific advice and support to the Australian Defence Organisation. DSTO is headed by the Chief Defence Scientist, Dr Roger Lough, and employs about 2100 staff, including some 1300 researchers and engineers. It is one of the two largest research and development organisations in Australia.

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Better hunting skills for new torpedo

DSTO is participating in a research program with the US Naval Undersea Warfare Center (NUWC) to develop a new heavyweight torpedo for the US and Australian navies.

The torpedo under development is known as the Mk48 Mod7 Advanced Capability (ADCAP) Common Broadband Advanced Sonar System (CBASS).

Researchers at DSTO have developed three techniques for enhancing the torpedo's ability to detect and track target submarines and surface ships.

These techniques are now part of the ADCAP Advanced Processor Build spiral development process, used to periodically enhance the torpedo's performance. They have been evaluated with real torpedo data and show good potential to improve the weapon's performance.

Synthetic emulation of ADCAP performance

The research is being undertaken in DSTO's Torpedo Systems Centre (TSC) using a variety of software and hardware tools acquired from the US, with training for DSTO staff in the operation of this complex system also provided by its US developers.

DSTO's research program has been facilitated by support from the Defence Material Organisation (DMO) and the CBASS Joint Project Office, with DMO funding a large proportion of the work carried out by DSTO.

Dr Daniel Solomon, Head of Torpedo Systems Group, says, "These tools enable the simulation of the entire torpedo's operation, including the emulation of the torpedo's detection and tracking performance."

"The main research tool, known as the Torpedo Analysis Facility (TAF), enables DSTO and Australian stakeholders to study the performance of the weapon with high fidelity in a laboratory environment at a significantly lower cost than at-sea evaluation of the weapon."

The TAF features a number of acoustic countermeasure and target models.

DSTO's Torpedo Systems Centre.

TAF system use

DSTO is working with the US to develop and validate a model of the Collins class submarine to enable use of the TAF for previewing joint US-Australian exercises. An initial model has been developed, and validation work has begun, using DSTO's numerical and scale models of the Collins boats.

DSTO is also developing a torpedo wake model to enhance the accuracy of the TAF system. Further enhancements and validation of the model will take place later this year.

The TAF will be used to undertake a joint study with the US to determine the performance of the ADCAP weapon in a wide variety of scenarios and environments of interest to both Australia and the US. It is currently being used to study the ADCAP's performance in scenarios of unique interest to Australia.

LiveSpaces: **intuitive workplaces of tomorrow**

Information and communications applications are being harnessed in new ways to give people at different locations the ability to work together more effectively with increased efficiency in both civilian and military contexts.

LiveSpaces technology in use.

"The aim of the research," says DSTO's Dr Rudi Vernik, "is to harness technological aids for decision-making that are intuitive to use, reducing the cognitive effort required for human-machine and human-human interaction so that decision-makers can direct their efforts to the task at hand."

"The technology must be very flexible and quickly adaptive in support of the capabilities of individuals and teams. The emphasis is on finding solutions that enhance creativity in the workplace."

"A particular challenge we are up against here is that, unlike the development process for physical capabilities such as aircraft and ships, the requirements for more intangible capabilities, such as command and control systems, are hard to define. Simply procuring devices and software may only result in lots of expensive shelf-ware without any increase in support for command teams."

In addition, the researchers are engaging with the problem of information overload. The perceived danger is that as the quantity of information made available increases, personnel will end up becoming 'data miners' in a quagmire of information rather than having their decision-making capabilities enhanced.

Advent of the 'smart workspace'

DSTO is responding to such problems through a major innovation called LiveSpaces. These are facilities that bring together a range of future command and control applications, ubiquitous computing technologies, telepresence systems, and new human interaction approaches in support of advanced teamwork activities.

The name LiveSpaces jointly reflects the notions that the environment is 'live' and changes depending on its context of use, while the 'space' aspect invokes the idea of through-wall environments that allow participation from individuals in other locations.

The LiveSpaces environment facilitates a technological capability known as integrated telepresence, meaning that people in dispersed locations can see and interact with each other as if they were collocated.

Similarly, the technology allows for the 'drag and drop' process of moving an image fluidly around screens in a room as well as sending it through walls to a room next door or across the globe.

All of the environmental parameters in the room, such as lighting levels, screen displays, applications, and media can be computer controlled so that particular work scenarios can be supported automatically by way of simple commands.

The range of military facilities that can be networked include advanced amenities such as the Future Operations Centre Analysis Laboratory

LiveSpaces technology in use.

(FOCAL) and other DSTO LiveSpaces, to LiveSpaces in operational command headquarters, training facilities and individual laptop computers in the field. This network of advanced innovation environments is being established as part of the related Command TeamNets project.

Focus on enhanced interaction

The LiveSpaces research is part of a broader program of research known as Cognitive and Social Informatics (CogSI).

A large amount of time and effort has gone into designing interfaces to make interaction simple and effective.

Research is being undertaken to improve the interface between humans and machines via the use of speech recognition, eye-gaze tracking and hand gestures, instead of the previously standard mouse and keyboard functionality. The research is also examining ways of improving the presentation of information.

A computer-animated virtual advisor has been devised as part of the command and control team, with whom the human operatives carry on an interactive dialogue in order to tailor information to their needs. Semantic machines that associate meaning with stored information can help decision-makers choose the information they have available to them. Intelligent social machines can support group interactions by providing the appropriate information at the right time and by improving group collaboration through the mediation of social protocols, language, and culture.

Additionally, the use of advanced computer graphics make it possible to immerse decision-makers in the information they need for decision-making, well beyond current capabilities such as 'dots on maps' displays.

Pondering on directions the research is taking here, Vernik proposes that "in the future we will talk more about human-information interaction rather than human-computer interaction since people will feel as though they are interacting directly with the information rather than the system presenting the information."

Cognitive and Social Informatics research

The LiveSpaces project is being carried out under the umbrella of the Cognitive and Social Informatics (CogSI) research program.

CogSI research investigates approaches that facilitate the symbiotic relationship between humans, information infrastructure, and intelligent applications in support of common understanding, coordinated decision-making, collaborative planning and synchronised action.

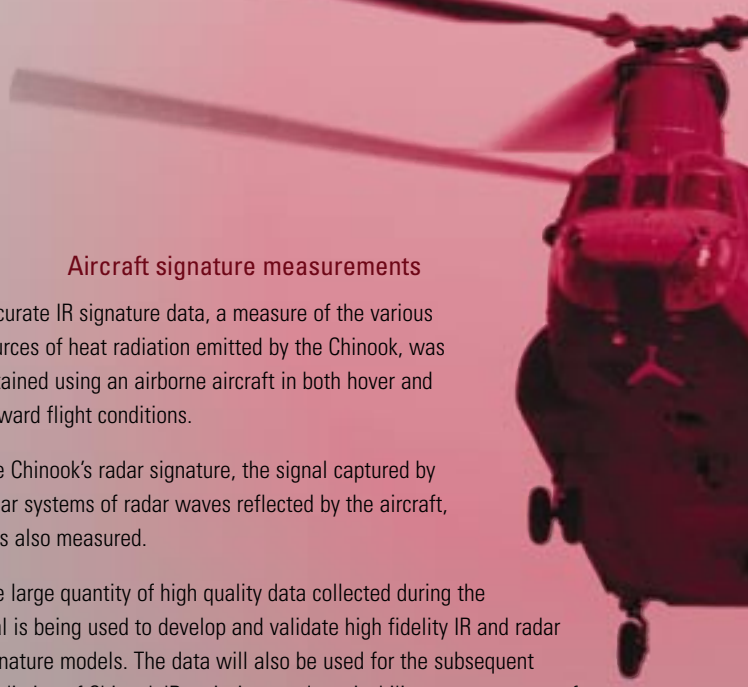
The focus of the work is at the intersection of two new discipline areas: cognitive informatics and social informatics. (Informatics: the study of the application of information science and technology to organisational and individual needs.)

Cognitive informatics looks at the application of information science and technology to enhance intelligence and computation processes in humans.

Social informatics studies the design, uses and consequences of information technologies, taking into account their interaction with institutional and cultural contexts.

DSTO's CogSI research draws on and extends these discipline areas to enhance the abilities of both individuals and teams involved in command and control.

Many-faceted protection for the Chinook



A number of research projects have been conducted by DSTO on countermeasures applications to protect the Australian Army CH-47D Chinook against missile attack.

The research work was carried out at RAAF Base Townsville in early 2006 to ready the CH-47D for deployment to Afghanistan.

Most of the work was commissioned as part of a project known as Trial Dapple, set up to pursue four objectives: development of infrared countermeasures against attack from shoulder-launched missiles, evaluation of the capacity of the missile-approach warning system (MAWS) to correctly detect missile launches, measurement and validation of the Chinook's infrared (IR) signature, and measurement of the aircraft's radar cross-section.

Trial Dapple was undertaken by the Australian Airborne Countermeasures Team (AACT), comprising personnel from the Joint Electronic Warfare Operational Support Unit (JEWOSU) and DSTO, and funded by the Australian Defence Force Countermeasures Development and Validation (CMD&V) capability.

The Trial Dapple team comprised about 25 DSTO people across several areas of expertise plus ADF personnel from JEWOSU. The CH-47D aircraft, flight crews and maintenance support were all supplied by 5 Aviation Regiment.

New missile detection system and countermeasures

The first objective of Trial Dapple was to test and compare potential IR countermeasure options, and select and validate optimal flare patterns and sequences.

Initial tests were conducted on all potential patterns and sequences before the best sequence was selected for detailed testing and validation.

Trial Dapple also involved testing of the AN/ALQ-156 pulse-Doppler radar MAWS that detects approaching anti-aircraft missiles.

The Doppler radar system had not been previously tested in Australia, since ADF aircraft have hitherto used missile warning systems that detect ultraviolet emissions from a missile launch rather than reflected radar signals from a missile in flight.

"Developing techniques to test this system at such short notice was a very challenging aspect of the exercise," says Mark Pitt, Head of DSTO's Electro-Optic Countermeasures group.

Aircraft signature measurements

Accurate IR signature data, a measure of the various sources of heat radiation emitted by the Chinook, was obtained using an airborne aircraft in both hover and forward flight conditions.

The Chinook's radar signature, the signal captured by radar systems of radar waves reflected by the aircraft, was also measured.

The large quantity of high quality data collected during the trial is being used to develop and validate high fidelity IR and radar signature models. The data will also be used for the subsequent prediction of Chinook IR emissions and survivability across a range of flight conditions, using hardware-in-the-loop computer modelling.

"Signature modelling and prediction are an essential part of countermeasures development and validation processes," explains Pitt.

A suite of positive outcomes

The AACT managed to complete its work on Trial Dapple in less than half the time normally required for such work.

While complete evaluation of the effectiveness of the missile warning and countermeasures suite normally takes from six to nine months, field trials and an initial assessment were finished in about three months over the Christmas period.

A comprehensive first-look report on the outcomes of Trial Dapple was provided to an Army board in March before the aircraft commenced operational missions. The teams will complete the detailed follow-on analysis over the next six months.

"One of the most pleasing aspects of the exercise was the fact that it brought a very diverse team together from different DSTO divisions," says Pitt. "The team worked really well together and all the stakeholders involved were really happy with the result."

Chinook in hovering flight.

Apparatus for conducting flare countermeasure trials.

DSTO researcher gathering radar signature data for the Chinook.

ADF Chinook helicopter.

Vibration testing

In addition to the Trial Dapple research activities, vibration testing was carried out on the Chinook's Countermeasure Dispensing System (CMDS) and aircraft support structure.

The AN/ALE-47 CMDS systems being installed to improve the CH-47D's electronic warfare self-protection (EWSP) systems feature externally mounted CMDS units as well as numerous internal components. The system dispenses flares and metallic 'chaff' to thwart various threats to the aircraft.

DSTO researcher David Conser explains, "All structures have natural frequencies which are defined based on their mass and stiffness distributions. Excitation at these frequencies results in resonance and can produce damaging structural loading."

"Hence, vibration testing was conducted to identify the natural frequencies of the local airframe structure supporting the external dispensers. Given this knowledge, dispenser firing intervals could be selected to reduce the impact of firings on airframe loading and fatigue."

Because of the time-critical nature of the project, results on the vibration testing were provided immediately on-site to Air Operations Support Group staff to facilitate ALE-47 dispenser sequencer programming by JEWOSU staff and the subsequent flight testing required to prepare for the system's integration into the aircraft.

Australian innovation **part of JSF development**



DSTO and Australian industry are playing a key role in the development of the future US combat aircraft, the Joint Strike Fighter.

The Joint Strike Fighter (JSF) has its genesis in an international collaboration mounted by the US Department of Defense in 1994 to replace several ageing front-line fleets in collaborating countries with a common family of aircraft.

Participating countries include the United Kingdom, Italy, the Netherlands, Turkey, Australia, Norway, Denmark, and Canada.

As part of that collaboration, the JSF Science and Technology Advisory Board (JSTAB) was formed to find world-leading technologies within JSF partner countries and evaluate and mature them for inclusion in the JSF.

Australia's contribution

In 2004, DSTO in collaboration with Australian industry and other Australian research organisations, submitted technology proposals aimed at meeting JSF design needs to solve System Development and Demonstration issues and to facilitate future upgrades.

According to Dr David Wyllie, Chief of DSTO's Air Vehicles Division, "Australia was extremely successful in bidding into the JSTAB process, securing seven of 21 projects world-wide. Of these seven, six were DSTO-based collaborations and one was from Australian industry. A total of 280 proposals were considered."

"The work in the successful projects covers a broad area including structural repair, weight reduction, corrosion protection, non-destructive inspection and prognostic health management. Four of the seven approved projects received funding from the JSF Project Office (JPO) in 2005."

The significance of the work arises in part from the fact that aircraft today are subjected to increasingly strenuous operations, and they are expected to perform for longer service lives. At the same time, the process of carrying out maintenance is becoming increasingly difficult with the advent of each new generation of aircraft.

Advanced airframe repair technology

Nearly all the surface of the JSF is to be constructed from new generation composite materials such as graphite/bismaleimide. While these new materials offer performance enhancements over the older generation graphite/epoxy materials, they are very difficult to repair because the much higher temperatures necessary for curing such composites are hard to achieve, and could also damage aluminium alloy substructures during repair processes.

At the same time, with the aircraft wing skins being built in nine pieces – seven pieces for the upper and two for the lower – the ability to repair the composite is critical, since part replacement would mean replacing a large portion of the entire wing.

An additional consideration for the maintenance program is the need to conserve the JSF's properties as a low-observable aircraft, meaning that repairs carried out must not impair the aircraft's original stealth radar signature.

The suite of repair techniques developed by DSTO for use on existing ADF platforms is being adapted for JSF applications together with the development of new methods for special JSF structural features and an integrated JSF repair suite that will extend life, prevent failures and correct defects.

Lockheed Martin X-35C Joint Strike Fighter. (Photos reproduced with permision of Lockheed Martin.)

Shape optimisation for structural detail design

Metallic aircraft structures often have features, typically holes, to provide access or for routing wiring and tubing. Inherently, the metallic structure around these holes is more highly stressed, and has to be locally padded to meet design fatigue life considerations, which increases the weight of the structure.

In recent years, DSTO has developed an advanced capability in the design of precise optimal shapes at such stress concentrating features.

The capability involves the use of existing DSTO computer codes interfaced with commercial codes. These are used to design optimal shapes that can locally reduce critical peak stresses that result in extended airframe structural fatigue life, and also lead to weight savings.

Validation of non-destructive inspection reliability

The process of non-destructive inspection (NDI) of aircraft structures is aimed at finding flaws that have the potential to cause failure over the service life of the aircraft.

Stringent probability of detection (POD) requirements are set, aimed at understanding the confidence of detection and to minimise the chance that a flaw will be missed and could lead to structural failure. Generally, an extensive and costly test program is needed to develop POD confidence limits for each inspection case.

The aim of this project is to develop tools to enable cost-effective determination of the reliability of NDI for the JSF. The end product will be a software tool based on existing techniques and DSTO algorithms.

Non-chromate conversion coatings

Corrosion-related maintenance in aircraft structure continues to be one of the most costly through-life support issues.

Previously, the protection of aircraft aluminium alloy structure has been undertaken with chromate-based coatings, but chromates are a known carcinogen, and the use of chromate-based materials is being more closely regulated by government legislation.

DSTO and CSIRO have developed techniques to protect metallic structures using alternative materials. This project aims to further develop a non-chromate conversion coating for high-strength aluminium alloys.

The technology provides an environmentally preferable alternative to the standard chromate-containing materials commonly used for corrosion protection of aluminium aircraft substrates.

Future JSF work to be undertaken in Australia

The work completed to date on these projects is currently under annual funding review by the JPO, and positive comments have been received from the US technical experts with regard to the quality of research and technical path taken.

Another three projects have been approved for funding, with work to commence this year.

Two of them involve DSTO research input: vibration-based prognostics and health management, and cold spray metal coating to replace cadmium coating as corrosion protection for high strength steel components.

The third project, aerospace prognostic health management, is to be carried out by an Australian company named 94th Peso.

Taking minutes by **digital secretary**

The advent of the automated digital minute-taker is fast approaching for the Australian Defence Force, with new speech recognition applications being readied for use by DSTO. The result is *Multi-Speak*.

The significance of the work begins with the widely held view that speech is the most natural form of communication between humans, and that human interactions with computers are also more efficient when carried out using speech rather than keyboard and mouse.

Correspondingly, the command post of the future is envisaged as an environment with embedded communications technologies that listen to the utterances of personnel, responding to voice command requests for information from computer-controlled networks and providing automatic transcription of discussions. Meanwhile, instructions to people are delivered by computer as near-natural synthesised speech. The advantages these technologies offer are to improve the efficiency of information management, collaborative planning and decision-making processes.

Prototype facilities including the Future Operations Concept Analysis Laboratory (FOCAL), the Intense Collaboration Space (ICS) and the Deployable Joint Force Headquarters (DJFHQ) are being used to evaluate such technologies.

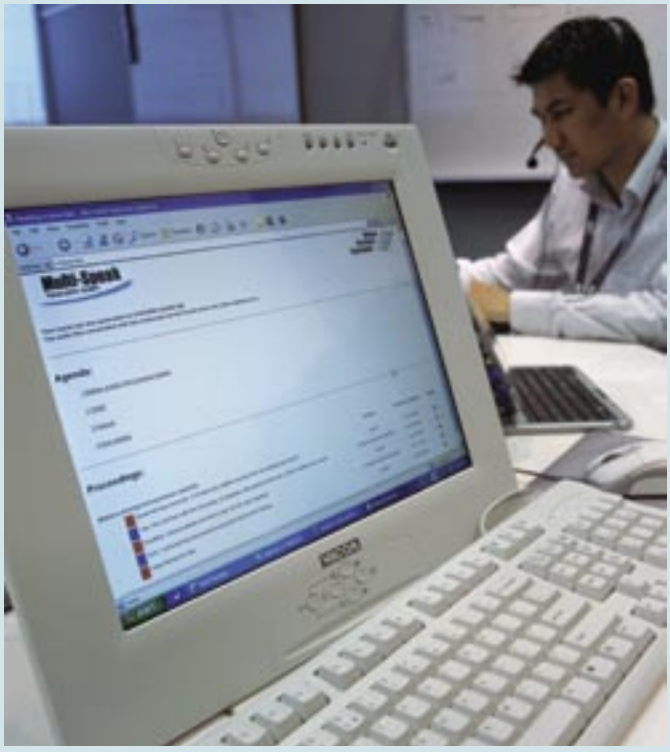
Automated data entry

One area of speech recognition work undertaken by DSTO is the automation of data entry.

According to DSTO researcher Ahmad Hashemi-Sakhtsari, DSTO has integrated the commercially available Dragon Naturally Speaking (DNS) speech recognition software as a speaker-dependent speech recogniser with Lotus Notes database and Excel spreadsheets for use in DJFHQ. He says, "Personnel using the system are able to select forms and sections in the forms and enter data in different fields using direct speech input rather than the keyboard and mouse. The range of processes using speech input includes formatted data entry, form-filling, and free dictation."

The voice of the data entry operator can be recorded by a microphone headset, or by an array microphone mounted on a desk or wall connected to a computer, meaning that the operator need not necessarily be tethered by cable to the system.

Before DNS can be used, a speech profile has to be generated for the user. This involves the process of training the software to decipher the prosodic features of individuals. By reading through passages of text, training models or templates that contain characteristics of each speaker are generated from units of sound known as phonemes.



PC screen showing Multi-Speak transcription of discussion.

To enable the use of DNS for Defence data entry purposes, DSTO has compiled a specific vocabulary of military acronyms and abbreviations as a web-based acronym manager that contains 54,000 acronyms and associated definitions.

Automatic voice transcription

For transcription of group discussions, the DSTO team has developed an application known as the Automatic Transcriber of Meetings (AuTM).

Each meeting attendee wears a microphone headset, and one or more participants have available a computer where all of the spoken utterances are converted to text and displayed.

Using Dragon Naturally Speaking software, the AuTM application records the words of each speaker as separate audio files, logs the start and stop times of every utterance, and transcribes these into text for display on the computer screens. Each delivery from the same speaker is colour-coded for easy visual identification of his or her contributions. The start times of agenda items are also recorded.

A moderator can step through agenda items and highlight significant aspects of the discussion such as motions and action items. AuTM can run on a single computer, or on multiple computers as a distributed application, with all of this information being displayed at near-real time rates.

The AuTM program highlights overlap between spoken utterances from the participants.

Later correction of speech recognition errors can be carried out off-line by checking the transcribed text against the matching audio file recording. The final transcript, as an HTML or Word document, can be processed by text summarisation and concept mapping tools.

The work on AuTM has now been readied for market in the form of a product called *Multi-Speak*, which is being released by Voice Perfect Systems under a commercialisation and licensing agreement with DSTO. *Multi-Speak* produces a fully interleaved and attributed text and audio record of the meeting, even when people speak simultaneously.

Factors that affect performance

The DSTO researchers have considered a number of factors that could influence the usability and effectiveness of transcription services in Defence.

These include background or environmental noises, and room reverberation. As countermeasures, the DSTO team has developed adaptive noise cancellation techniques for incorporation into meeting rooms.

The research is also investigating the effects of 'disfluencies' (speaker-generated artefacts) such as 'ums', 'urs', coughs and tongue clicks. By modelling disfluencies and subtracting these artefacts from the speech to be recognised, the recognition vocabulary can be restricted to legitimate utterances, and so, will result in a more efficient transcription process.

Consideration is also being given to the effects of telephony bandwidth limitation on the performance of speech recognition systems. This is to better understand the application of the technology in teleconferencing situations.

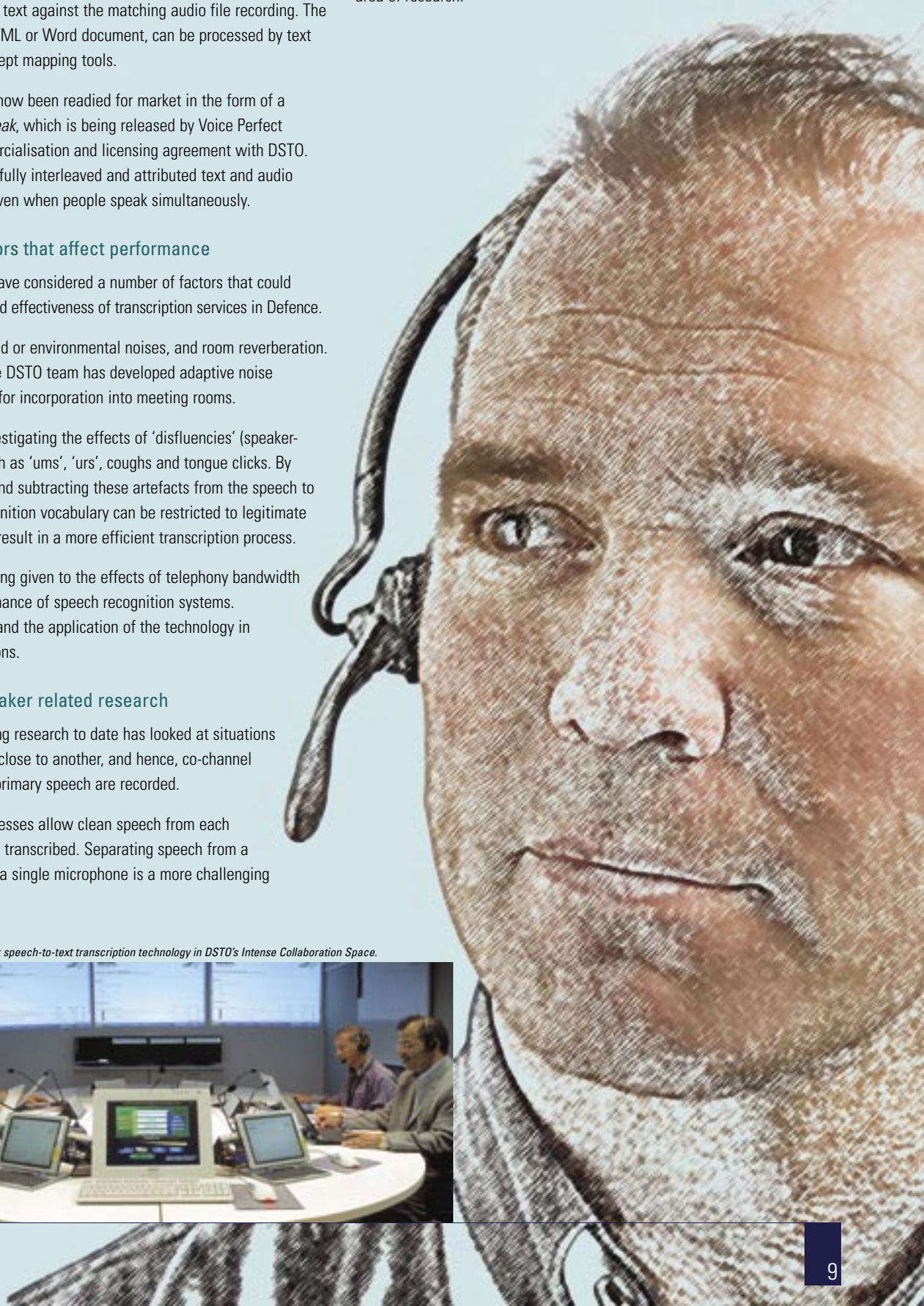
Speaker related research

DSTO's speech processing research to date has looked at situations in which one speaker is close to another, and hence, co-channel interference as well as primary speech are recorded.

Speaker separation processes allow clean speech from each speaker to be separately transcribed. Separating speech from a group of speakers using a single microphone is a more challenging aspect of the work.

To capture and monitor the work activities of several individuals in a room, it is necessary to locate and track speakers as they move around. Speaker localisation and tracking applications used in multimedia teleconferencing can be used to steer microphone arrays and cameras to capture individuals as they work, in order to ascertain, for example, particular patterns of behaviour.

DSTO, working with university researchers, is making good progress in this area of research.



Researchers trialling Multi-Speak speech-to-text transcription technology in DSTO's Intense Collaboration Space.

Studying crewing options for **airborne refuelling**

The Australian Defence Force is acquiring five new air-to-air refuelling aircraft to support F/A-18, F-111, AEW&C Wedgetail, and Joint Strike Fighter aircraft. DSTO has been carrying out studies on crewing options before the new refuellers enter service in 2009.

Graphic mock-up of proposed MRTT in operation.

Initial planning for the RAAF's new Multi-Role Tanker Transport (MRTT) assumed that the flight crew for air-to-air refuelling operations would comprise four persons; two pilots (Pilot Flying and Pilot Not Flying), a Mission Coordinator (MC) and an Air Refuelling Operator.

However, the choice of the Airbus A330 for the MRTT presents an opportunity to re-evaluate this configuration, due in part to the high level of automation built into the Airbus systems.

DSTO research has contributed to this re-evaluation by modelling MRTT crew tasks to ascertain the likely impact of removing the MC from the crew.

Crew modelling process

The modelling was conducted using a widely used human-performance modelling tool known as the Integrated Performance Modelling Environment (IPME), developed collaboratively by defence research agencies in the United Kingdom and Canada.

DSTO researcher Dr Christopher Best explains the intricacies of using this modelling tool.

"Work scenarios are broken down into a collection of individual tasks which are then arranged into networks according to how the tasks relate to each other – for example whether they are more-or-less standalone, in the sense that their execution does not depend on the execution of preceding tasks, or alternatively, whether interdependencies exist between tasks, in the sense that one particular task cannot be executed until one or more other tasks have been completed."

Each of the tasks can be analysed as a series of demands, termed variously 'input', 'central', 'output' and 'time pressure'. Input demand arises from the acquisition of information from external sources via visual displays or auditory signals in the course of monitoring communications and warnings. Central demand arises from mental operations such as memorisation, calculation or decision-making required by the task. Output demand arises from the process of delivering responses. Time pressure demand is the rate at which the task must typically be performed to meet a deadline.

The IPME modelling simulates crew performance for their various assigned tasks, taking into consideration the realities that operators are often required to perform multiple tasks, sometimes simultaneously or nearly

The Multi-Role Tanker Transport

Australia's new air-to-air refuelling fleet will consist of Airbus 330-200 type aircraft, used as passenger airliners on many international routes, adapted for MRTT use.

In December 2004, Defence signed a $1.4 billion contract with Spanish company, European Aeronautic Defence and Space Construcciones Aeronauticas SA (EADS CASA) to carry out the conversion work.

Acquired as a replacement for the Royal Australian Air Force's ageing Boeing 707 fleet, the aircraft will be fitted with electronic warfare self-protection equipment, and training simulators will also be provided.

The basic A330 aircraft will be produced in Europe, with four of the five being modified and converted into MRTT aircraft by Qantas in Brisbane.

Australian industry will also be closely involved in the design work, project management, and production of aircraft components and engine parts for export.

Work to be undertaken by Australian industry and the associated technology to be transferred to Australia is expected to exceed $500 million over the life of the MRTT aircraft. Negotiation of the through-life support contract is continuing.

simultaneously; interference can occur between tasks, particularly if the task places demands on the same classes of operator resources; and different tasks may place higher or lower overall workload demands and time pressure on the operator.

A crew with or without MC

For the MRTT analysis, data inputs in the form of task times and estimates of task workload were obtained via consultations with RAAF air-to-air refuelling and Airbus aircraft subject-matter experts.

To quantify the difference between MRTT crews with and without the MC, a relatively high workload situation was modelled. The hypothetical scenario chosen involved boom refuelling of the future Joint Strike Fighter aircraft.

An unexpected event was included in the scenario to model the crew's responsiveness to unforseen circumstances with three and four-person configurations. At a random time during the simulated air-to-air refuelling exercise, a request to transit and conduct a new refuelling operation in another area was introduced, requiring that the crew make changes to the flight plan.

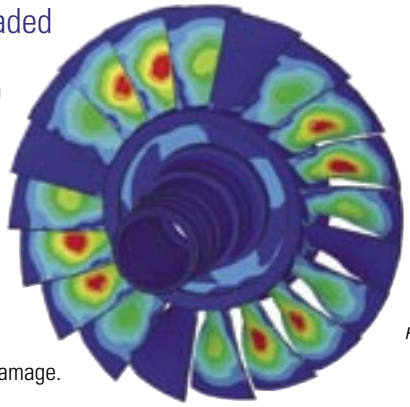
This particular event was chosen as a realistic possibility that crews will face, and as such is typical of a broad range of unexpected, relatively high workload events that would normally involve the MC.

IPME modelling was used to simulate refuelling missions for three and four-person crew configurations, with and without various adverse workload-increasing conditions such as poor weather and difficult communications. The number of missions simulated in the course of investigating all of these factors amounted to around 10,000.

The upshot of this work is that a crew of three has been shown to be adequate for MRTT operations.

High-cycle fatigue predictions for **gas turbine engines**

DSTO is carrying out research on 'blisks' (bladed disks) in new generation aircraft engines to develop predictive models of high-cycle fatigue (HCF) problems.

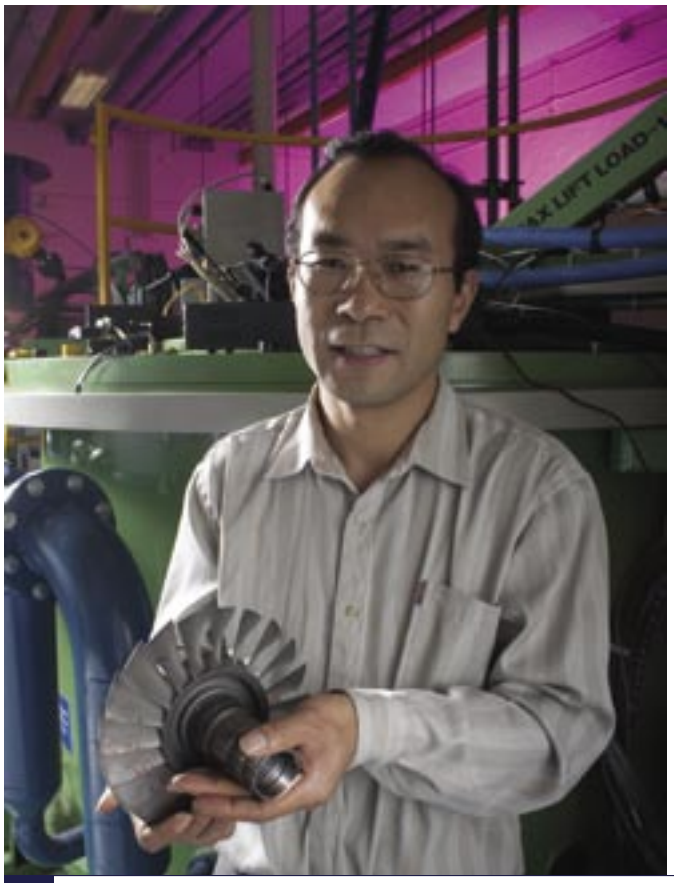


Finite element model of a blisk.

One major cost in the operation of the gas turbine engines used by the RAAF has been damage to blades caused by objects ingested by the engine, commonly referred to as foreign object damage.

The engine types currently in service on RAAF aircraft are based largely on 1950s and 1960s design methodologies that use disks fitted with individual blades. Any damage sustained was generally confined to the blade or blades affected, and remedial measures generally involved repair or replacement only of these affected blades.

With blisks, however, the disk and blades are integrated into a single unit. The advantage of this form of design is the elimination of critical stressed locations at fixings that secure the blade root to the disk, which enables weight savings, but a downside is that any damage arising can be considerably more problematic.



DSTO researcher Dr Jian Hou with blisk.

The effects of damage on blisks

DSTO researcher Dr Jian Hou has been studying the impact of damage on blisk behaviour.

According to him, "If a blade is damaged, the dynamic behaviour of other blades in the blisk will be changed dramatically, and the other undamaged blades may fail in a very short time. In a worst case scenario, this may lead to cracking in the body of the blisk with catastrophic consequences for flight safety."

"In effect, some components that were less critical in conventional engine design will be very critical in future generation engines. The challenge is to understand the new set of problems related to durability and reliability," he says.

Blisks have been used in smaller aircraft engines for some time already, and are now being applied in large new generation engines, such as those for the proposed Joint Strike Fighter.

Extending the service life of blisks

Costing in the region of $100,000 to $250,000 each, blisks are currently seen to have a service life of only about five hundred hours because of uncertainties associated with HCF.

The research is aimed at further developing DSTO's predictive capabilities for HCF, finding a smarter way of detecting cracks, and investigating the likely behaviour of cracks, in particular whether their behaviour is dangerous or benign.

Using this investigative approach, it may be possible to establish whether each blisk can safely remain in service for longer, thereby delivering significant cost savings. It is also anticipated that the research will help determine the optimal maintenance schedule for blisk blades and ensure that blade repairs meet certification requirements.

The work at DSTO is being carried out in association with the US Air Force Research Laboratory in Ohio, USA.

Human Machine Interface trials for Echidna

DSTO's Black Hawk simulator.

In February this year, the first of three simulation trials was conducted in DSTO's Black Hawk simulator in Melbourne to study the operation of an electronic warfare (EW) suite to be installed on Black Hawk and Chinook aircraft.

The Echidna 2A Electronic Warfare Self Protection Suite, developed by BAE Systems, integrates Radar Warning, Missile Warning, Countermeasures Dispensing, and EW Control capabilities on both aircraft types.

Fitted in the Black Hawk cockpit simulator were working versions of the hardware and software. The aircrew 'flew' 16 missions dealing with a range of threats to test different features of the Human Machine Interface.

After each mission, aircrew were guided through structured interviews to elicit feedback on the suitability of the design features in order to improve on the system.

BAE Systems will now update the design, and further testing will be conducted around the middle of the year.

Virtual clearance for submarine flares and markers

ADF Collins class submarine.

DSTO recently carried out an extensive series of simulations to investigate the trajectory of submarine-launched flares and markers from the Collins class submarine's submerged signal ejectors.

The purpose of the study was to determine the potential for these items to recontact the submarine after ejection. Two submarine scenarios were simulated: one involving a disabled submarine, and one making an emergency ascent.

The simulations, carried out on DSTO's computational fluid dynamics facility (a high performance computer system), showed that the flares and markers would clear the submarine under all scenarios tested.

The Navy's Submarine Force Element Group has suggested possible follow-on work, including full-scale validation from a Collins class submarine and further simulations to support other operational requirements.

Explosion containment trial

DSTO was requested by the National Security Science and Technology (NSST) Unit of the Department of Prime Minister & Cabinet to conduct a performance evaluation of commercially available containment devices used to suppress the blast pressure and fragmentation effects from explosive devices.

A highly instrumented trial was conducted at the Port Wakefield Proof and Experimental Establishment in South Australia. A range of different types and sizes of commercially available devices with differing configurations and modes of deployment were tested. The explosive charges ranged from 100 grams to 5 kilograms of TNT equivalent explosive mass.

Preliminary results showed that the majority of the tested devices provided a significant reduction in blast overpressures in the near field, and some demonstrated a useful reduction in fragmentation threat effects.

The trial outcomes will be disseminated via NSST to appropriate State and Federal counter terrorist organisations. Reports on individual containment tests will be provided to participating containment suppliers.

CALENDAR

24 - 28 Jul 2006	Science of Autonomy Symposium 2006 Adelaide Contact: Dr Anthony Finn Tel: 08 8259 6771 http://www.dsto.defence.gov.au/4198/
9 Aug 2006	TecXpo 2006 DSTO Edinburgh, Adelaide Contact: Sue Phillips Tel: 08 8212 7688 http://www.dsto.defence.gov.au/events/3329/
16 Aug 2006	DSTO Industry Conference DSTO Edinburgh Contact: Julie Bebbington Tel: 08 8259 4025 http://www.dsto.defence.gov.au/events/4549/
31 Aug - 1 Sep 2006	11th Australian Workshop on Safety Related Programmable Systems Melbourne Contact: Dr Tony Cant Tel: 08 8259 6700 http://www.safety-club.org.au/
4 - 6 Sep 2006	Maritime Systems and Technology for Defence, Security and Safety Nice, France http://www.mastconfex.com/conference.asp
19 - 21 Sep 2006	Safeguarding Australia 2006: The 5th Homeland Security Conference and Exposition Canberra Convention Centre, Canberra http://www.safeguardingaustraliasummit.org.au/
21 - 24 Sep 2006	Australasian Society of Aerospace Medicine Annual Conference Launceston Email: paula@leishman-associates.com.au
26 - 28 Sep 2006	Defence Operations Research Symposium Australian Defence Force Academy, Canberra http://hubs.dsto.defence.gov.au/sites/DORS/conf
18 Oct 2006	ICT Outlook Forum MCG Melbourne Contact: Katie Bosanquet Tel: 02 9280 1443 Email: ictoutlook@zestevents.com.au http://www.ictoutlookforum.com.au
19 - 22 Oct 2006	Defence Health & Australian Military Medicine Conference Brisbane Exhibition & Convention Centre, Brisbane Email: jane@leishman-associates.com.au
24 - 27 Oct 2006	Land Warfare Conference 2006 Brisbane Contact: Moreen Pyper Tel: 08 8259 5455 Email: lwcc@dsto.defence.gov.au

ADS14/1-07/2006 Cover image: Water tunnel testing of the JSF model.